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Preparation and Use of Sprays

Spray Calendar

By. Wm. Stuart

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Director's office, chemical, horticultural and veterinary laboratories are at the Experiment Station building, at the head of Main street; botanical and entomological laboratories are at Williams Science Hall, University place.

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BULLETIN 113—PREPARATION AND USE OF SPRAYS

By William Stuart

Introduction

The aim of the present publication is to present simple, concise and up-to-date directions for controlling the commoner diseases and insects attacking Vermont crops, by the use of fungicides, insecticides or other preventive measures. While there is little that is new contained in its pages, the many requests for such information show that it is needed and will be appreciated. Similar but smaller publications have been issued by the Station from time to time in the past, but they are now out of date and mostly out of print.

There are, however, other good reasons for the issuance of such a bulletin. The preventable losses from apple scab, codling moth and potato blight are so great that such a publication ought to serve a good purpose in pointing out the ready means whereby their ravages may be lessened.

Out of about one hundred fruit growers replying last season to a circular letter, only seven reported having sprayed their trees. One of this number had sprayed four times, two twice and four only once. Apple scab was reported by these one hundred correspondents to be more or less prevalent throughout the State, nearly one-third of them mentioning it as being present in greater or less degree in their orchards.

It is well understood that the codling moth is an almost omnipresent menace to successful fruit growing; yet its work may readily be checked and the percentage of wormy apples reduced to a minimum. Its control would place thousands of dollars annually in Vermont farmers' pocketbooks.

Yet another consideration of even greater importance is the fact that Vermont's potato growers repeatedly suffer large loss from blight and rot. This, in a season like the last, must have approached or exceeded a hundred thousand dollars. That such losses should be met in view of our present knowledge of preventive measures leads one to believe that methods are not clearly apprehended.

Objects of Spraying

The protection derived from spraying crops is of two sorts, viz.: (1) From parasitic fungi; (2) From injurious insects. In the latter case we have to deal with both leaf eating and sucking insects. For convenience these plant parasites may be divided into three classes according to treatment:

A. *Fungous diseases* controllable in a large measure by the intelligent application of fungicides. Bordeaux mixture is the best example of this class.

B. *Leaf eating or fruit eating insects* more or less readily controlled by the judicious application of arsenical poisons, either in liquid or dry form.

C. *Sucking insects*, more or less controllable by the application of caustic solutions or powders that kill by contact, or by some volatile property. Kerosene emulsion is a good example of the first, air slaked lime of the second, and pyrethrum powder of the third.

FUNGICIDES AND INSECTICIDES ARE EFFECTIVE ONLY WHEN PROPERLY USED

The efficacy of any treatment is, as a rule, directly proportional to the intelligence exercised in its use. The best results can only be obtained when the operator is thoroughly informed as to the object of spraying and the best methods to employ in combating fungous diseases and insects. He should learn when to spray and how to spray, and then do it thoroughly. One spraying in season is more effective than a dozen out of season. Old solutions should not be used. A spray pump with a good agitator capable of maintaining a high pressure and a nozzle delivering a fine spray are prime requisites in spraying fruit trees or potatoes.

SPRAYING APPARATUS

The bewildering array of spray pumps now on the market makes it necessary for the fruit or vegetable grower to exercise some care in the selection of a spraying outfit. In general it may be stated that to insure durability all working parts of a spray pump should be of brass, and if all submerged parts are of brass so much the better. Generally speaking, the bucket pump and knapsack sprayer are only adapted for use in the garden. The hand power barrel or tank pump is suitable for all kinds of spraying. Power sprayers operated by gasolene engine, compressed air or other motive power are desirable where large orchards or trees are to be sprayed. The spray nozzles used should be capable under sufficient pressure of throwing a very fine spray.

FORMULAS AND DIRECTIONS FOR MAKING FUNGICIDES AND INSECTICIDES

A. FUNGICIDES

I. BORDEAUX MIXTURE

Copper sulphate or blue vitriol.....5 pounds
Quick lime .....5 pounds
Water .....50 gallons

Bordeaux mixture may be made in varying proportions and strengths. No one method or formula is universally applicable, yet certain details ought to be observed in its preparation to secure the best results. The main point is to make a mixture in which the copper and lime will remain suspended for the greatest possible length of time. To secure this the two ingredients should be handled in separate wooden or earthen vessels, diluted to one-half or two-thirds of the required volume, and then simultaneously poured together slowly into a third vessel, the mixture being vigorously stirred during pouring and for some time afterwards. A quick and convenient way to dissolve copper sulphate is to suspend it in a cheesecloth or bran sack just below the surface of the water in a tub containing, say, ten gallons. The mixture should be strained through cheesecloth or other suitable material to remove coarse particles. Old solutions should not be used, since freshly made ones only are serviceable. Stock solutions of each separate ingredient may be prepared, if desired, which, unlike bordeaux mixture, will keep indefinitely if the ingredients are kept separate. In preparing stock solutions it is customary to make a gallon represent a pound of the copper sulphate or lime.

The following statement on pages 97 to 99 is reprinted from the seventeenth report and inserted here so that the matter that has to do with spraying may all be in one publication. There is an illustration showing the method of use of the gravity system in the report which will be sent to anyone without charge on request.

Bordeaux mixture is perhaps the most common and universally employed of fungicides. Moreover it is probably more often mismade and misused than any other fungicide, because people who use it are not apt to provide the necessary facilities for properly making and applying it.

The horticultural department has devoted considerable attention during the past two seasons to simplifying the labor of making bordeaux mixture. Two objects were in view:

1. To avoid lifting so far as practicable.

2. To promote the formation of a fine precipitate, and, therefore, of a perfect mixture.

When dilute solutions of lime and copper sulphate come together in equal proportions, that is to say, both brought together simultaneously in a third vessel, the precipitate formed is so finely divided that it remains in suspension a much greater length of time than when a strong solution of one and a weak or strong one of the other are thrown together. Anyone in the least conversant with the use of bordeaux mixture readily recognizes that a mixture which holds the solid particles in suspension for a considerable length of time is superior to one from which they separate quickly.

A gravity system.—To obviate the necessity of lifting the mixture when filling the spray pump barrel a lean-to shed was made to serve the purpose of a temporary support to a two-tier stage or platform. On the upper platform were disposed the barrels which were intended for stock solutions of lime and copper sulphate, and, also, those in which these solutions were to be diluted preparatory to mixing in the third vessel on the platform below. These dilution vessels were provided with good sized faucets which were brought sufficiently close together to allow the liquid flowing from both at the same time to be caught in a spout which emptied into the barrel on the lower level. The two solutions simultaneously flowing into this spout form bordeaux mixture during their flow into the spout, the precipitate being extremely fine and passing through the cheesecloth strainer. A pipe with a valve protruded at right angles from the mixing vessel to the spray pump barrel, which by means of an ell and short pipe conducted the prepared bordeaux mixture into the barrel. In this way a perfect mixture is obtained, since the reaction takes place in the short spout and on the strainer and is continued by the agitation in the mixing barrel. The stock solutions only need be lifted. This system is best used where water pressure is available to carry the water to the upper platform. It is conceivable, however, that if such a platform were built near a well, by increasing the length of the pumpstock, the water could be raised to the desired level with little extra effort and that thus much of the drudgery of making bordeaux mixture would be eliminated, besides securing the additional advantage of a perfectly prepared mixture.

Stock solutions.—Much time may be saved in the preparation of considerable quantities of bordeaux mixture if stock solutions of lime and copper sulphate are prepared in advance. In the work performed at this Station 50 pounds of copper sulphate are dissolved in 50 gallons of water in one vessel, while a like number of pounds of lime are slaked and diluted with as many gallons of water in another. The formula used in making the bordeaux is the so-called 1-10 formula, that is, 1 pound of copper sulphate or of lime, as the case may be, to every 10 gallons of water. Hence in making up 50 gallons of bordeaux 5 gallons each of the stock solutions contained the required amounts of these ingredients. These are diluted to 25 gallons each, after which the faucets are opened and the whole process becomes self-operative even to the filling of the spray tank.

Some authorities recommend stronger stock solutions, 2 pounds copper sulphate to each gallon, while others claim that a saturated solution (about 3 pounds of the copper sulphate per gallon) is the bet-

ter one to use. The advantage of a saturated solution lies in the fact that it is always of a constant strength, as evaporation simply entails the precipitation of a proportionate amount of the copper salt, whereas in more dilute solutions evaporation of water causes a more concentrated solution than that prepared at the outset. When the weaker stock solution is used, and some is carried over to the next period of spraying, a mark should be placed on the barrel in order that it can be restored to its original volume when required for use. Large quantities of copper sulphate are most easily and quickly dissolved by enclosing the crystals in a coarse sack—bran sack for example—and suspending them in the vessel of water, being careful to keep it near the surface.

The successful use of fungicides depends on other factors than simply the proper making of a spray mixture. The application of the fungicide should be thorough, which can only be assured when a pump is employed capable of maintaining a high pressure and provided with suitable nozzles for throwing a fine spray. Success or failure hinges also on the application or non-application of the fungicide at the proper time, or, as it may be expressed, the critical period. One application at the right time is more valuable than a dozen at the wrong time. "A stitch in time saves nine."

The secret of success in spraying for fungous diseases is that of exercising care in the preparation and application of the right fungicide at the right time and for the right purpose.

II. COPPER SULPHATE SOLUTION

Copper sulphate ..... 3 pounds
Water ..... 50 gallons
For use in the early spring (April) when trees are dormant.

III. AMMONICAL COPPER CARBONATE SOLUTION

Copper carbonate ..... 5 ounces
Ammonia ..... 3 pints
Water ..... 50 gallons

Directions.—Dissolve the copper carbonate in the ammonia. When desired for use dilute to 50 gallons.

Owing to the very volatile nature of the ammonia it must be kept in a well-stoppered earthen or glass vessel. An earthen jug is a convenient receptacle. If the ammonia is diluted to twice its volume a greater proportion of the copper carbonate will be dissolved. Frequent agitation of the liquid will hasten solution.

IV. POTASSIUM SULPHID SOLUTION (LIVER OF SULPHUR)

Potassium sulphid ....1 ounce
Water ....4 gallons

Especially valuable as a spray for mildew of gooseberry and downy mildew of grape.

V. CORROSIVE SUBLIMATÉ (MERCURIC CHLORID)

For potato scab

Corrosive sublimate ....2 ounces
Water ....15 gallons

Dissolve the corrosive sublimate in hot water in an earthen or wooden vessel and dilute to required strength.

Caution.—Corrosive sublimate is extremely poisonous, hence care should be exercised to prevent accidents.

VI. FORMALIN (FORMALDEHYDE)

(a) *For potato scab*

Formalin ....1 pint
Water ....30 gallons

Immerse tubers for two hours in either of the above solutions previous to cutting and planting. The solution may be used for six or seven lots of potatoes within two or three days.

(b) *For oat smut*

Formalin ....1 pint
Water ....50 gallons

Enclose seeds in a loose sack, and immerse from one to two hours; remove and spread out to dry.

Another method of treatment is to spread the seeds on a floor or canvas and thoroughly sprinkle them with formalin solution; then rake together in a conical pile and cover with an old blanket for three to four hours, after which time uncover and spread out to dry.

VII. COMBINATION FUNGICIDE AND INSECTICIDE

The addition of some arsenical poison to bordeaux mixture enables one to accomplish two objects with a single application. The insecticide added may be arsenate of soda, Disparene, paris green or any other of the various arsenical poisons used in the relative proportions indicated in the following pages:

B. POISONOUS INSECTICIDES

VIII. PARIS GREEN

(a) *For fruit trees*

Paris green	1 pound
Lime	3 pounds
Water	150-200 gallons

(b) *For potatoes*

Paris green	1 to 2 pounds
Lime	3 pounds
Water	100 gallons

Paris green and lime are most effectively combined when the lime is slaking. During this process constant stirring is necessary to insure the complete neutralization of the free arsenious acid which all paris green contains, which if not neutralized is apt to burn the foliage. Dilute to the consistency of thick whitewash and allow it to stand a few hours before making up to volume for use.

IX. ARSENATE OF LEAD

This may be made from the raw materials or purchased in prepared form under such trade names as "Disparene" or Swift's or Adler's Arsenate of Lead. Disparene is a special preparation of the Bowker Insecticide Co. of Boston, and can be purchased in 2, 5, 10 and 25 pound cans and 100 pound kegs at prices ranging from 25 cents per pound for the smaller package to 15 cents per pound for the 100 pound keg. The formula for making arsenate of lead is:

Lead acetate (sugar of lead)	11 ounces
Arsenate of soda	4 ounces
Water	50 gallons

Both lead acetate and arsenate of soda dissolve more readily in warm than in cold water. To prepare, dissolve each in two quarts warm water; when dissolved pour them together in a barrel of water and stir.

Disparene is used at the rate of from two to three pounds to fifty gallons water. It is in the form of a grayish-blue paste and should be dissolved in a small quantity of water before adding to the larger volume mentioned. An objection urged against the commercial products is that they do not remain in suspension as long as does the freshly prepared home-made article, and at the same time are consid-

erably more expensive. Lead acetate costs 11 cents a pound and arsenate of soda 9 cents, making 50 gallons cost only 10 cents, whereas enough Disparene to make this amount would cost from 30 to 45 cents.

X. ARSENITE OF LEAD

The arsenite of lead is very similar to the arsenate and like it has a commercial preparation known to the trade as "Pink Arsenoid." The following formula is recommended in the preparation of arsenite of lead:

Lead acetate	21 ounces
Arsenite of soda	4 ounces
Water	50 gallons

The "Pink Arsenoid" is used at about the same rate as Disparene, viz.: two to three pounds to 50 gallons water. It does not remain in suspension as long as does the home-made article and is also more costly.

While the formulas which are given for arsenate and arsenite of lead differ materially in amounts of lead acetate, it is questionable if in the majority of cases such differences should exist. This statement is made as the outcome of an incident that came to the attention of the writer a year ago in connection with the purchase of a lot of arsenate of soda from a large and a thoroughly reliable chemical supply firm. Prices were quoted by this firm on arsenate of soda, but the package when opened was found to be labelled "Arsenite of Soda." On inquiry of the firm the following reply was elicited: "In regard to arsenate of soda, permit us to explain that we have only one commercial article, which is a mixture of arsenate and arsenite, and goes under the name of arsenate or arsenite, and is always given when arsenate or arsenite is ordered. We have only the pure article of true arsenate of soda, put up in one and five pound bottles, which would cost you 30 cents per pound, bottles included, against 9 cents for the technical mixed article." It would appear from this that arsenate and arsenite of lead as ordinarily made from commercial chemicals are one and the same, with the exception that the formulas call for different amounts of lead acetate and in some cases of the arsenate and arsenite of soda, thus materially increasing the cost of the latter solution.

XI. ARSENITE OF SODA (KEDZIE FORMULA)

White arsenic	2 pounds
Sal-soda	8 pounds
Water	2 gallons

Preparation.—Boil until the arsenic is all dissolved, approximately fifteen minutes. Replace water evaporated in boiling, then place in an earthen vessel, cork tightly and label "POISON." One pint of this stock solution is equivalent to four ounces of paris green and is sufficient for 45 gallons water. Lime should be added to the diluted solution before spraying in order to avoid injury from burning of foliage.

XII. HELLÉBORE

In dry form

Hellebore .....1 part
Flour .....2 to 3 parts

Especially valuable against currant and gooseberry worm.

C. CONTACT INSECTICIDES

XIII. (a) KEROSENE EMULSION

Kerosene .....2 gallons
Hard soap (or 1 quart soft soap) .....½ pound
Water .....1 gallon

Preparation.—Dissolve the soap in water by boiling, remove from flame and add oil to soap solution or *vice versa*, then churn violently with a hand force pump or spray pump until the whole is reduced to a creamy consistent mass.

Use.—For scale insects before leaves appear, dilute with 6 to 10 parts water; for soft bodied insects dilute with 15 to 20 parts water.

(b) KEROSENE AND MILK EMULSION

Kerosene .....2 gallons
Milk (sour) .....1 gallon

Churn into a creamy mass as in preparation above. Keep in air-tight jar; for use dilute same as in preceding formula.

XIV. LIME-WASH

This mixture is especially effective against the oyster shell-bark louse when applied in late winter or early spring, at the rate of from one to two pounds of fresh lime to each gallon of water. It also seems to have some fungicidal properties.

XV. LIME-SULPHUR-SALT WASH

Various proportions of lime, sulphur and salt are advocated by station entomologists, horticulturists and botanists. The formula used

at this Station last spring was similar to that recommended by Marlatt:[1]

(a) Quicklime ....30 pounds
Sulphur (ground) ....20 pounds
Salt ....15 pounds
Water ....50 gallons

The following formula is thought to be sufficiently effective for oyster shell-bark louse:

(b) Quicklime ....20 pounds
Sulphur (ground) ....15 pounds
Salt ....15 pounds
Water ....50 gallons

The lime is slaked in a barrel by adding just enough water, preferably warm, to slake it. During the process of slaking add the sulphur and stir thoroughly. When the heat begins to subside add the salt and additional water, after which the cooking process must be continued for one or two hours. If steam is available this can be done in a barrel. If fire is to be used the wash must be prepared in an iron vessel. The material should be cooked until it turns a brick dust red. Only a portion of the water need be added for the cooking process.

XVI. LIME-SULPHUR-SODA WASH

Quicklime ....20 pounds
Sulphur (ground) ....15 pounds
Caustic soda ....4 to 6 pounds
Water ....50 gallons

Preparation.—Follow directions as given for preceding but instead of cooking with steam or fire heat, the boiling process begun by the lime is carried on by the addition, in two or three amounts, of the caustic soda which in dissolving causes intense heat. The advantage of the lime-sulphur-soda wash over that of the preceding is that it obviates the necessity of using steam or fire. It is thought by some that this wash is not quite as effective as is the original lime-sulphur-salt wash. These washes give the best results when applied in early spring. They are not only effective as a contact insecticide, but are also known to control the leaf curl of peach and plum, as well as being quite as effective as bordeaux mixture as a first application for apple scab.

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[1] U. S. Dept. Agr. Farmers' Bul. 127, p. 22 (1900).

XVII. PYRETHRUM

(a) *As a spray*

Pyrethrum .....1 ounce
Water .....3 gallons

(b) *In dry form*

Pyrethrum .....1 part
Flour .....2 to 3 parts, or

it may be used without admixture of flour. Pyrethrum, if fresh, is an effective remedy for fighting soft bodied insects, as the cabbage and currant worm and plant aphis.

XVIII. TOBACCO

(a) *Liquid form*

Tobacco stems .....1 pound
Water .....2 gallons

(b) *Dry form (tobacco dust)*

Preparation.—Boil the stems and strain the liquid, then make up to volume (2 gallons); especially valuable against aphis. In dust form it may be employed for the same purpose as in liquid form. It is also sometimes used as a repellant for the cucumber beetle and other enemies of the cucumber family.

Following is a list of the standard fungicides and insecticides. The Roman numerals prefixed correspond to the references in the spray calendar on pages 106-108, as well as to the formulas—pages 96-105. The page numbers refers to the directions.

I. Bordeaux mixture—Page 96.
II. Copper sulphate solution—Page 99.
III. Ammonical copper carbonate solution—Page 99.
IV. Potassium sulphid—Page 100.
V. Corrosive sublimate solution—Page 100.
VI. Formalin solution—Page 100.
VII. Combination fungicide and insecticide—Page 100.
VIII. Paris green—Page 101.
IX. Arsenate of lead—Page 101.
X. Arsenite of lead—Page 102.
XI. Arsenite of soda—Page 102.
XII. Hellebore—Page 103.
XIII. Kerosene emulsion—Page 103.
XIV. Lime wash—Page 103.
XV. Lime-sulphur-salt wash—Page 104.
XVI. Lime-sulphur-soda wash—Page 104.
XVII. Pyrethrum—Page 105.
XVIII. Tobacco—Page 105.

COMMON FRUIT PESTS AND METHODS OF COMBATING THEM

	Disease or insect	Treatment	Approximate time and number of treatments			
			First	Second	Third	Subsequent treatment
Apple and Pear	Scab and leaf spot	Fungicides	I or II before buds open	I or VII after blossoms fall	I 10-15 days later	Repeat in 2 weeks*
	Canker and blight	Cut out and burn	I or II before buds open			
	Apple maggot	Destroy all windfalls and affected fruits				
	Codling moth	Arsenites	VII, VIII, IX, X, or XI after blossoms fall			
	Borers	Dig out and destroy				
	Oyster shell bark louse	Contact insecticides	XIII, XIV, XV, or XVI before buds open	XIII when young appear		
	Aphis	Contact insecticides	XIII before buds open	XIII or XVI when young appear	Further spraying with XIII or XVIII if necessary	
	Slug	Air slaked lime or dust when slugs appear				
Plum and Cherry	Brown rot, leaf spot, shot-hole fungus, leaf curl	Destroy affected fruit and twigs Fungicides	I, II or XV, XVI before buds open	I or VII after blossoms fall	III when fruit is ripening if fungus is prevalent	
	Black knot	Cut out and destroy	I or II before buds open			
	Curculio	Jarring trees and arsenites	VII, IX, X and XI after blossoms fall	Repeat 10-15 days later		
Grape	Downy mildew	Fungicides	IV or dry sulphur at first appearance of disease	Repeat in 5-10 days, and continue at intervals till fruit is ripe		
	Leaf hopper	Contact insecticides	XIII or XVIII when pest appears	Repeat in 5-10 days if necessary		

*If scab is prevalent and climatic conditions favorable for its development

COMMON FRUIT PESTS AND METHODS OF COMBATING THEM—Continued

	Disease or insect	Treatment	Approximate time and number of treatments			
			First	Second	Third	Subsequent treatment
Currant and Gooseberry	Mildew	Fungicides	IV when buds begin to open	Repeat every 10-15 days till fruit is ripe		
	Leaf spot	Fungicides	I before buds open	VII ⅔ strength 2 weeks later		
	Worm	Arsenites or hellebore	VIII, IX, X, XI or XII when worms appear	Repeat if necessary		
Raspberry and Blackberry	Anthracnose and rust	Cut out and burn Fungicides	I before leaves start	I ⅔ strength when leaves expand	I repeat if necessary	
	Leaf spot	Fungicides	Same as for anthracnose and rust			
Strawberry	Leaf blight	Fungicides	I ⅔ strength when leaves start	I ⅔ strength 10-15 days later		
	Leaf roller	Burn foliage after fruit is picked				
COMMON PESTS OF THE VEGETABLE GARDEN AND METHODS OF COMBATING THEM						
Bean	Anthracnose	Fungicides	I ⅔ strength or III when true leaves appear	Repeat in from 10-15 day intervals till crop is matured		
Cabbage Cauliflower and Brussels Sprouts	Black and soft rots	Preventive measures	Destroy all affected plants, practice rotation of crops			
	Maggots	Preventive measures	Protect stem of newly set plant with paper collar*			
	Worms	Arsenites or pyrethrum	VIII or XVII when worms appear	Repeat as often as necessary	Air slaked lime and dry dust may be us'd	

*Destroy affected plants, rotate crops

COMMON PESTS OF THE VEGETABLE GARDEN AND METHODS OF COMBATING THEM—Continued

	Disease or insect	Treatment	Approximate time and number of treatments			
			First	Second	Third	Subsequent treatment
Cucumber and Muskmelon	Blight and leaf spot	Fungicides	I when vines begin to run	Repeat at intervals		
	Wilt	Preventive measures	Destroy affected plants; rotation of crops			
	Striped beetle	Arsenites	VII, IX or X as soon as bugs appear; repeat as often as necessary			
Potato	Blights and rot	Fungicides	I or VII about middle July	Repeat in 10-15 day intervals if weather conditions are favorable to blight		
	Scab	Disinfectants	Treat seed before planting V or VI for two hours			
	Colorado and flea beetle	Arsenites	VIII, IX, X or XI when bugs appear, after middle of July use VII			
Tomato	Blight and rot	Fungicides	I when fruit is half grown	Repeat in 10-15 days	III when fruit begins to ripen	
	Worm	Hand picking or arsenites	VIII or IX when worms appear			